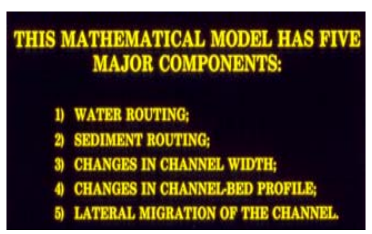
FLUVIAL-12 MODELING OF SEDIMENT, BANK EROSION, AND CHANGES IN GEOMORPHIC PROCESSES ON THE FEATHER RIVER FROM OROVILLE TO HONCUT CREEK

MODEL SELECTION

Modeling is particularly useful for understanding the river's natural state and predicting responses to human activities. Models can be used to determine the following:

- Predict future changes based on past changes,
- Determine the geomorphic effects of new structures such as bank protection, dams, bridges, etc prior to installation,
- Determine sediment transport, and sediment transport changes caused by dams and other structures.

Four models were selected from those available for further evaluation. These are the Sediment Analysis Model (SAM), Hydrologic Engineering Center's HEC-6, GSTARS 2.1, and Fluvial-12. Fluvial-12 was selected because of its ability to model bank erosion, availability of expert consultation, and because it is an erodible boundary model. An erodible boundary model can not only model changes in bed elevation but also channel width and bed topography induced by the channel curvature.



FLUVIAL-12 OUTPUTS

DWR-ND already owns Fluvial 12 and we have worked with Dr. Howard Chang, the model developer, on several related projects. He has also worked on projects worldwide, including the Three Gorges Dam in China, and projects on the Feather River for Pacific Gas and Electric Company. Data inputs to the model are compatible with previous studies and available hydrologic data. The Fluvial 12 model was therefore selected as the primary model for the assigned task.

THIS CROSS-SECTION SHOWS BANK EROSION AND LATERAL MIGRATION

THREE GORGES DAM IN CHINA

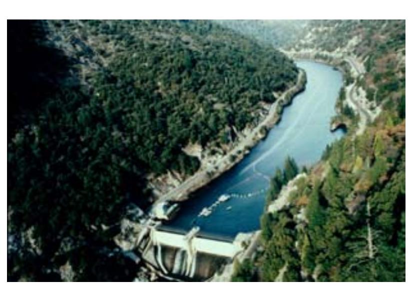
MODEL CAPABILITIES

The computer program FLUVIAL-12 is a mathematical model that is formulated and developed for water and sediment routing in natural and man-made channels. The combined effects of flow hydraulics, sediment transport, and river channel changes are simulated for a given flow period.

Fluvial 12 is capable of modeling changes over time in the following physical parameters:

- Channel scour and fill, aggradation and degradation.
- Changes in channel cross-section, including depth and width.
- Changes in bed material composition, including coarsening or fining.
- Armoring, the condition where the surface layer becomes coarser than the underlying bed material, is also predicted and modeled.
- Changes in cross-section location caused by bank erosion, sediment deposition, and meandering.
- Changes in water surface and bed elevation profiles.
- Changes in Manning's n, or the roughness of the channel.
- Changes in sediment transport.
- Changes in river curvature.

These inter-related changes are coupled in the model for each time step. While this model is for erodible channels, physical constraints, such as bank protection, grade-control structures and bedrock outcroppings, may also be specified. Applications of this model include evaluations of general scour at bridge crossings, sediment delivery, channel responses to sand and gravel mining, channelization, and dams.



FLUVIAL-12 MODELING FOR FEATHER RIVER DAMS

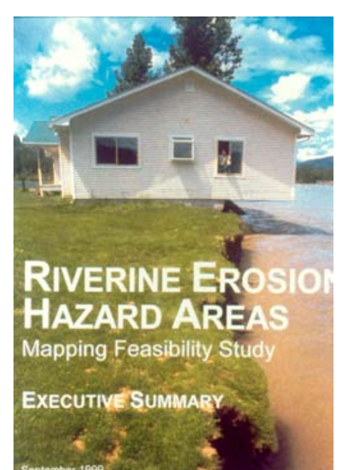
COMPONENTS OF FLUVIAL-12

The FLUVIAL model has the following five major components: (1) Water routing, (2) sediment routing, (3) changes in channel width, (4) changes in channel- bed profile, and (5) changes in geometry due to curvature effect. These inter- related components are described in the following sections.

Water routing provides temporal and spatial variations of the stage, discharge, energy gradient and other hydraulic parameters in the channel.

The sediment routing component for the FLUVIAL-12 model has the following major features:
(1) Computation of sediment transport capacity using a suitable formula for the physical conditions,
(2) determination of actual sediment discharge by making corrections for sorting and diffusion,
(3) upstream conditions for sediment inflow, and
(4) numerical solution of the continuity equation for sediment.

An increase in width at a channel section depends on sediment removal along the banks. The maximum rate of widening occurs when sediment inflow from the upstream section does not reach the banks of this section while bank material at this section is being removed. River banks have different degrees of resistance to erosion; therefore, the rate of sediment removal along a bank needs to be modified by a coefficient. For this purpose, the bank erodibility factor is introduced as an index for the erosion of bank material.



FLUVIAL-12 MODELING FOR BANK EROSION

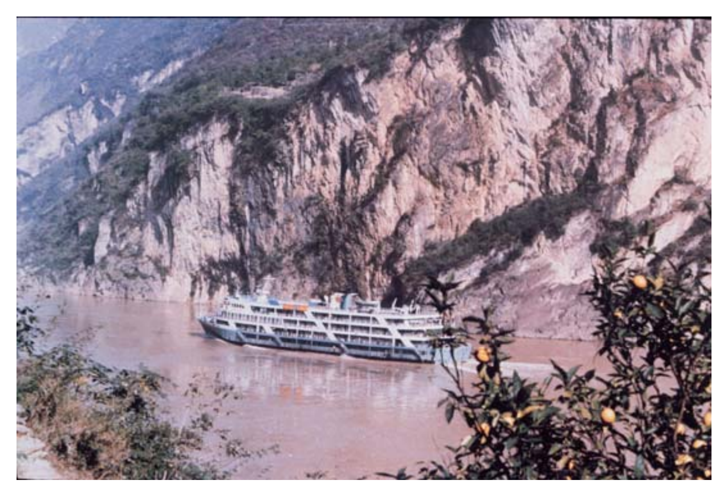
MODELING SEDIMENT TRANSPORT FOR ROCK CREEK AND CRESTA

TESTING AND CALIBRATION OF FLUVIAL-12

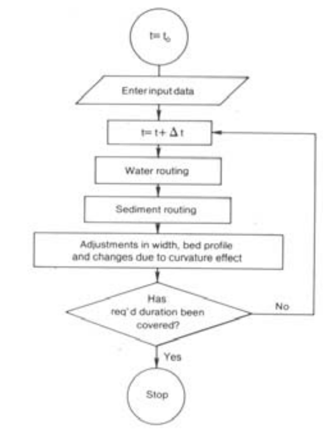
The accuracy of a mathematical model depends on the physical foundation, numerical techniques, and physical relations for momentum, flow resistance and sediment transport. Testing and calibration are important steps to be taken for more effective use of a model. Major items that require calibration include the roughness coefficient, sediment transport equation, bank erodibility factor, and bed erodibility factor.

To determine the sensitivity of flow, the sediment transport, and the channel changes caused by the variation of each variable, different values of the variable need to be used in simulation runs and the results so obtained are compared.

Field data are generally used for test and calibration of a model. The required information includes channel configuration before and after the changes, a flow record, and sediment characteristics. Data sets with more complete information are also more useful. The FLUVIAL-12 has undergone test and calibration using many data sets.



SEDIMENT MODELING FOR THREE GORGES DAM



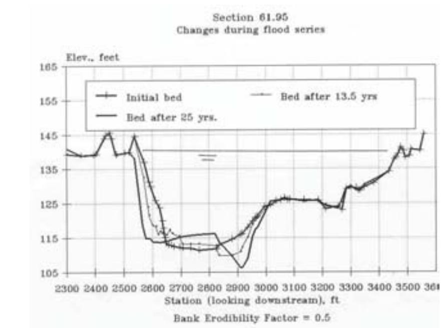
ROUTING

SP-G2 TASK 8: MODELING SEDIMENT TRANSPORT

DWR identified available sediment transport models, reviewed use by different agencies and consultants, then selected the Fluvial-12 model as the most appropriate for the study reach. Fluvial-12 will use and evaluate a variety of bedload transport equations to determine those appropriate for the Feather River. The selected program will output data suitable for developing bedload transport curves. These will be used to help determine Oroville Dam outflows that will move gravel in the Feather River. These curves will also predict when additional gravel needs to be added. In addition, this Task will:

- Estimate bank erodibility factors
- Estimate Manning's coefficient of roughness
- Develop flow datasets for representative cross-sections in the study reach
- Calculate the water surface slope of the channel
- Identify reaches of bank protection
- Measure water temperature
- Estimate thickness of erodible bed
- Measure sediment characteristics
- Decide whether unsteady flow modeling is appropriate
- Conduct bed material sampling and determine bedload sediment size fractions
- Locate and re-survey cross-sections and determine characteristics

It will also determine at which flows the gravel bed begins to mobilize. This is critical in determining flow conditions that degrade spawning riffles. It is also important in designing spawning gravel rehabilitation measures. The model is a useful tool for predicting future changes caused by various hydraulic scenarios.



SAMPLE MODEL OUTPUTS